Volume 3 NOVEMBER 15, 1928 Number 5

BULLETIN

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OF THE

AMERICAN PHYSICAL SOCIETY

PROGRAM

OF THE

MINNEAPOLIS MEETING

NOVEMBER 30—DECEMBER 1, 1928

PUBLISHED BY THE AMERICAN PHYSICAL SOCIETY
SIX ISSUES EACH YEAR

The American Physical Society

OFFICERS OF THE SOCIETY FOR 1928

President	K. T. COMPTON	Princeton University
Vice-President	H. G. GALE	University of Chicago
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COUNCIL

The Council of the Society consists of the president, vice-president, secretary, treasurer and managing editor as given above, and all living past presidents and eight elected members as follows:

Past president: A. A Michelson, Carl Barus, E. L. Nichols, Henry Crew, W. F. Magie, Ernest Merritt, R. A. Millikan, J. S. Ames, Theodore Lyman, C. E. Mendenhall, and D. C. Miller.

Elected Members: F. C. Blake, W. F. G. Swann, A. H. Compton, R. T. Birge, P. D. Foote, G. W. Stewart, L. J. Briggs and H. L. Bronson.

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MINNEAPOLIS MEETING NOVEMBER 30—DECEMBER 1, 1928

The 153rd regular meeting of the American Physical Society will be held in Minneapolis, Minnesota, at the new Physics Laboratory of the University of Minnesota on Friday and Saturday, November 30 and December 1, 1928. The special feature of the meeting will be the formal dedication of the new Physics Laboratory of the University.

Symposium. On Friday afternoon at 1:30 o'clock there will be held in the Physics Auditorium, Room 150, a Dedicatory Symposium.

The program will open with an address by PROFESSOR HERMANN WEYL of the University of Zürich:

"*Laws of Conservation and Rules of Intensity in Quantum Mechanics.*"

This address will be followed by four papers on electron impact phenomena:

"*Scattering of Electrons*" by PROFESSOR K. T. COMPTON of Princeton University.

"*Quantum Theory of Aperiodic Effects*" by PROFESSOR E. U. CONDON of Princeton University AND DR. J. R. OPPENHEIMER.

"*Photo-ionization and Recombination*" by DR. F. L. MOHLER of the Bureau of Standards.

"*Motions of Positive Ions in Ionized Gases*" by DR. IRVING LANGMUIR AND DR. LEWI TONKS of the General Electric Company.

Dinner. On Friday evening at 6 o'clock the members of the Physical Society will be the guests of the University at a dinner to be held in the ballroom of the Minnesota Union. DEAN G. S. FORD will preside. The program will consist of an address of welcome by PRESIDENT L. D. COFFMAN and response by the President of the Society. There will follow short addresses by DR. W. F. G. SWANN AND PROFESSOR S. C. LIND.

Dedicatory Exercises. The formal Dedicatory Exercises will be held in the Physics Auditorium on Friday evening at 8:15 o'clock. PRESIDENT L. D. COFFMAN will preside. The program as announced will be:

Presentation of building on behalf of Regents—HONORABLE FRED B. SNYDER.

Acceptance—DEAN J. B. JOHNSTON.

Acceptance—PROFESSOR H. A. ERIKSON.

Dedicatory Address—PROFESSOR JOHN ZELENY "The Place of Physics in the Modern World."

Luncheon. Luncheon on Friday will be in the ballroom of the Minnesota Union from 12 to 1:30 o'clock. On Saturday the members will leave the Laboratory at 12 o'clock and drive via St. Anthony Boulevard, Memorial Drive, Glenwood, and Lake of the Isles to the Minikahda Club for luncheon. After luncheon they will drive via Calhoun, Harriet, Minnehaha and River Road back to the Laboratory, arriving about 2:30 o'clock.

Visit to Research Laboratory for Physics and Biophysics of the Mayo Clinic. Arrangements will be made whereby those interested in visiting the laboratories of the Physics Section of the Mayo Clinic at Rochester, Minnesota, may do so Saturday evening by purchasing their return ticket via Rochester.

Hotel Accommodations. The Headquarters for the meeting will be in the New Nicollet Hotel. Rates with bath, $2.50 and up.

CALENDAR

Friday

10:00—12:00 a.m.	Physics Auditorium, Room 150, Papers 1–14.
12:00—1:30 p.m.	Luncheon. Ballroom, Minnesota Union.
1:30—5:00 p.m.	Dedicatory Symposium. Physics Auditorium. (For program see above)
6:00—8:00 p.m.	Dinner. Ballroom, Minnesota Union. (For program see above)
8:15 p.m.	Dedicatory Exercises. Physics Auditorium. (For program see above)

Saturday

10:00—12:00 m.	Physics Auditorium. Papers 15–26.
12:00—2:30 p.m.	Drive and luncheon at the Minikahda Club.
2:30 p.m.	Physics Auditorium. Papers 27–40.

The supplementary papers Nos. 41–44 may be called for at the end of any regular session.

Papers Nos. 1, 5, 6, 15, 16, 33, 40 and 41 will be read by title.

Titles and abstracts of the papers to be presented are given in the following pages. These abstracts have not been corrected by the authors. After correction, they will be published in an early number of the Physical Review. Authors should send corrections to the Editor of the Physical Review at University of Minnesota, Minneapolis, Minnesota.

HAROLD W. WEBB, *Secretary*

November 15, 1928.

PROGRAM

FRIDAY MORNING AT 10 O'CLOCK

Paper No. 1 will be read by title.

1. Surface friction in tubes not of circular cross section. S. R. PARSONS, University of Arkansas.—The equations for frictional resistance to turbulent passage of a fluid through a tube of circular cross section have been adapted for use with tubes of other forms of section, by the use of expressions involving hydraulic radius rather than diameter. Schiller has shown (Zeits. Math. u. Mechanik, **3**, 2, (1923)) that the method is applicable to a number of forms, including, square, rectangular, and triangular; and Davies and White (Roy. Soc. Proc., A **119,** 92, (1928)) have extended it to pipes of very narrow rectangular section. Computations based on Lonsdale's experiments with water flowing through the annular space between two coaxial cylinders (Phil. Mag. **46,** 163, (1923)) show that the method is applicable also to this case. Further computation shows that the equation of Lees for surface friction in circular tubes (Roy. Soc. Proc. A **91,** 46, (1914)) may be adapted to each case mentioned above, by substituting four times the hydraulic radius for the diameter of the tube. (This hydraulic radius is defined as the ratio of the area of cross section to the total perimeter, which is one half as great as the value used by Schiller.)

2. Entrophy and probability. W. S. KIMBALL, Michigan State College.—The subject is treated by a new method distinct from (a) the kinetic method and (b) the statistical method. The procedure is characterized by elementary probability methods without reference to collisions or molecular ensembles in phase space. The probability of the state of each molecule is calculated separately and the product for all molecules gives the probability of the state of the gas. Six axioms are laid down: The probability of a particle's occupying a position in ordinary space equals the probability of its occupying any other position in ordinary space. Likewise with velocity space, momentum space, orientation space, and angular momentum space. These five axioms are generalized into a single axiom that includes all the others: The probability of a particle's having a position in action space equals the probability of its having any other position in action space. These axioms are supported by the Relativity Principle, and Liouville's Theorem. On the other hand they disagree with the quantum theory, but may be modified so as to incorporate it by restricting a particle's position in action space to integral multiples of Plank's h. The key note of the procedure is to measure probability by the range in action space (of not more than six dimensions) that includes each molecule. The new expression for "weight" is equivalent physically though of different form from the usual one from statistical mechanics involving factorials. Maxwell's distribution law is shown to be most probable by this new method of derivation, and the known expressions for entropy and the chemical constants for different types of gas are obtained. Plank's "Zustandsumme" or summation state is shown to be the momentum range per molecule in its average energy state, divided by the square root of e, once for each degree of freedom.

3. Measurement of the intensity of high frequency magnetic fields. ROY H. MORTIMORE, State University of Iowa.—A method was developed for the measurement of the intensity of magnetic fields in the range of wave-lengths from 12 to 30 meters. Two methods were employed. By the first method the current in a circuit was computed from vacuum tube voltmeter readings of potential drop across a standard inductance. The values for current thus obtained were compared with the readings of thermo-ammeters in the range for which they were calibrated. For larger currents the instruments were shunted and calibrated for particular wave-lengths by the standard inductance method. The instruments thus calibrated were used to measure the currents in a Helmholtz coil and from these measurements the field intensities within the space enclosed by the coil were computed. By the second method

the electromotive force induced in a single turn coil placed in the field to be measured was indicated by a vacuum tube voltmeter. The field necessary to induce the observed electromotive force was computed. Good agreement was found between the results obtained by the two methods.

4. A direct-current amplifier for measuring very small currents. J. M. EGLIN, Bell Telephone Laboratories, Inc.—A direct-current amplifier consisting essentially of a Wheatstone bridge, having the amplifying tube in one arm and a balancing tube in another, was recently described by Wynn-Williams (Proc. Camb. Phil. Soc. **23**, 810, (1927)). This has been developed to give a constant amplifications for currents in either direction up to 10,000 times the lowest measurable value. The amplification and the lowest measurable current are alterable together by changing the resistance introduced between the grid and filament of the amplifying tube. With tubes of high insulation, the amplification can be made as large as 10^6; and the measurable current as low as 10^{-14} ampere. Some improvements of the circuit are: (1) the insertion of a resistance in series with the tube in one arm of the bridge to "compensate" for variations in plate and grid battery voltages; (2) the suspension of the tubes to protect them from mechanical vibrations; (3) the use of tubes with pure tungsten filaments, to avoid changes in contact potentials, and with plates enclosing the filaments completely, to lower the effects of wall charges. In a "null" method of using the circuit, the values of the grid resistance and an auxiliary potential introduced in the grid-filament circuit are sufficient to determine the measured current.

Paper No. 5 will be read by title.

5. Amplification of photo-electric currents. HAROLD A. WHEELER, Johns Hopkins University.—A convenient and rugged amplifying apparatus has been developed for the direct measurement of very small photo-electric currents (or x-ray ionization currents). The light beam is interrupted by a rotating sector wheel at a frequency of 150 cycles per second; the resulting 150-cycle alternating component of the photo-electric current is amplified more than 10^9 times by a three-stage, broadly resonant, vacuum-tube amplifier; the amplified current is rectified by a synchronous commutator with adjustable brushes; and the rectified current is measured by a portable micro-ammeter whose deflection is directly proportional to the photo-electric current. The factor of proportionality is determined by introducing a known current into the photo-electric-cell circuit from a second set of brushes on the same commutator. The only time lag in this measurement is the period of the micro-ammeter about two seconds. The accuracy of measurement of very weak currents is limited by fluctuation phenomena in the amplifier. In selectivity against fluctuations and other disturbances, this system is equivalent to a sharply resonant amplifier with a resonance curve only one-half cycle in width. In the experiments performed, the fluctuations caused a "probable error" of between 10^{-14} and 10^{-13} ampere (for a single observation). Improvements have been outlined which should reduce this error to below 10^{-15} ampere.

Paper No. 6 will be read by title.

6. Excitation of band spectra. JOSEPH KAPLAN AND E. L. KINSEY, University of California at Los Angeles.—The β bands of nitric oxide are only weakly excited in electric discharges and strongly excited in active nitrogen. Their excitation in active nitrogen is by collisions of the second kind, while in discharge tubes it is due to electron impact. This difference in the excitation of spectra by electron impact and by collisions of the second kind can be explained by means of the Franck-Condon curves for the two levels that are involved in the transition. The most probable transition for electron impact is one in which the vibrational motion in the upper level is determined by the instantaneous values of the separation of the atoms r and their relative momentum p_r. The difference in binding between the upper and lower states of the β bands is very large and explains the non-excitation of the known bands. Their excitation by collisions of the second kind is interpreted as meaning that the energy transfer during a collision of the second kind requires a time so long that the transfer does alter the instantaneous values of r and p_r. It is therefore possible to make diagonal jumps between two Franck-Condon curves, by collisions of the second kind.

7. New bands in the secondary spectrum of hydrogen. G. S. MONK AND A. E. ELO, University of Chicago.—Using the electronic and vibrational levels associated with the Balmer lines, which have been obtained by Richardson, the wave-numbers of the remaining lines of the band groups have been computed, and compared with measured lines in the tables of Gale, Monk, and Lee, and of Poettker. Only Q branches are found, a fact in agreement with the work of Richardson, whose results for the P and R branches are fragmentary. The absence of the P and R branches in the present work is probably attributable to the faintness of the new bands, only the Q branches being strong enough for observation. The reality of the branches thus found depends in part on the accuracy of Richardson's data, which are better for the α, β, and γ electron levels than for higher levels. Some bands attributable to the H_3 molecule have been found in the new measurements of Gale, Monk, and Lee, and of Poettker. The evidence for the reality of these bands is discussed.

8. The band spectrum of fluorine. H. G. GALE AND G. S. MONK, University of Chicago. —New Measurements show the bands of this spectrum to consist of P, Q, and R branches with alternate weak and strong lines in each branch. The Q branch is about twice as strong as the P or R branch. Two of the strongest bands whose initial points lie at $\nu=16378.8$ and $\nu=17439.5$ have been completely analyzed and three fainter bands at $\nu=15337.6$, $\nu=17075.0$, and $\nu=18550.0$ partly analyzed. There are strong perturbations in all the bands in both frequency and intensity, which have heretofore masked their true character. These perturbations are in the initial state, with a single perturbation probably belonging to the final state. The following values have been obtained:
$B_0'=0.840$, $B_0''=1.095$, $I_0'=32.9\times10^{-40}$, $I_0''=25.3\times10^{-40}$, $\omega_0'=847$, $\omega_0''=1132$, $\alpha=0.015$.
The structure and intensity relations indicate that the bands are of the $'S\rightarrow'P$ type. Neglecting strongly perturbed intensities, the best plates show the ratio of intensity of weak to strong lines to be about 1:3, indicating that the fluorine atom possesses a nuclear spin of one-half (in quantum units).

9. The metastable states of atomic nitrogen. K. T. COMPTON AND J. C. BOYCE, Princeton University.—A study of the extreme ultraviolet spectrum of nitrogen excited by controlled electron impacts, together with a consideration of the spectra obtained by Hopfield, Fowler, and Millikan and Bowen, has enabled us to extend the analysis of near-visible lines made by Kiess so as to give practically the entire spectral structure predicted by the Hund theory. The "ground" state $2p^4S$ has a term value of about 117345, as found by Hopfield. The two next lowest states are $2p^2D_{2,3}$ and $2p^2P_{1,2}$ at about 98143 and 88537 respectively. These states are metastable. The separation of the D terms is about 5, and that of the P terms probably not more than 1. *Active nitrogen.* The energies of these states are 2.37 and 3.56 volts, respectively. These are just the energies of the entities in active nitrogen which Kaplan and Cario, working in this laboratory, found necessary to account for production of the "afterglow" by excitation of the ^1S metastable molecules, and for excitation of other spectra in "dark" active nitrogen. There seems, therefore, to be no doubt that the two types of metastable atoms and the metastable molecule are singly or jointly responsible for the varied phenomena of active nitrogen.

10. The diffraction of light by a circular opening and the Lommel wave theory. MASON E. HUFFORD AND HAROLD T. DAVIS, Indiana University.—In a paper published by E. Lommel in 1886 the conditions for a maximum or minimum of light intensity in a diffraction pattern produced by light passing through a circular opening are derived. The equation for maxima and minima involves the Bessel functions and the Lommel U-functions. These equations and the Lommel theory have not been verified except for very small diffraction patterns produced by light through comparatively small distances. Some experiments in which very large diffraction patterns were produced by light passing through comparatively large distances offered an opportunity to verify the theory through a much larger range. Professor H. T. Davis has contributed new equations for calculating the Lommel U-functions involved in calculating the intensity of light at 256 points along a radius in the pattern. Graphs of the intenisty in the pattern have been made. From these at points representing maxima and minima numerical values were taken for substituting in the Lommel equations for calculating

the radii of the diffraction rings. These calculated radii have been compared with radii measured on the diffraction patterns.

11. Combination scattering in liquids. R. M. LANGER, National Research Fellow, and W. F. MEGGERS, Bureau of Standards.—The scattered light of modified wave-length predicted by quantum theory and recently found experimentally by Raman and Krishnan differs from the incident by a frequency equal to an absorption frequency of the scattering substance. This frequency shift produces a wave-length shift which increases with the wave-length of the scattering line. It would then be desirable for accurate measurement to use as long as exciting wave-length as possible. Prism spectrographs which, because of their light gathering power, have been used exclusively hitherto have very poor dispersion in the visible. In the ultraviolet their increased dispersion and the relative increase in intensity of modified lines are offset by the decreased wave-length shift and especially by the chemical action of the incident light on the scattering substance which often gives a great deal of trouble. Moreover many interesting substances are opaque in the ultraviolet. We have, therefore tried for the effect with a 21 ft. concave grating and have succeeded in getting good plates in 1 to 2 hours exposure. Under this high dispersion the modified lines vary in character, some being complex, some hazy, some unsymetrically shading off to the violet. What is more surprising is that others, for example the ones in benzene corresponding to a shift of 992 wave-numbers, are comparable in sharpness with the exciting Hg lines and the wave-lengths of such lines are measurable with an accuracy of one or two hundredths Angstrom unit.

12. Temperature variations of the Raman effect in quartz. F. G. BRICKWEDDE AND M. F. PETERS, Bureau of Standards.—Photographs were obtained of the Raman Effect in crystalline quartz over a range of wave-lengths from 2400 to 5000A and of temperatures from −180° to 550°C. The intensity of the anti-Stokes lines corresponding with the 21μ absorption band increase greatly with rising temperatures. Stokes lines change only slightly with temperature, the line accompanying 2536 decreasing slightly with rising temperature. The anti-Stokes lines corresponding with an 81μ band increase less rapidly than do those corresponding with 21μ band. The corresponding Stokes line decreases in intensity. These results are in qualitative agreement with the assumption that intensities of Raman lines vary as the populations of the initial states which give rise to them, the population of the states varying with temperature in accordance with Boltzmann's law. Displacements from the exciting line of Raman lines corresponding with 21μ and 81μ bands decrease with rising temperatures. This is expected if these infra-red bands move to longer wave-lengths. With rising temperature Stokes lines corresponding with the 21μ band—sharp at room temperature—become diffuse, and anti-Stokes lines—diffuse at room temperature—become broader and more diffuse. The intensity of the Raman scattering increases markedly in passing from longer to shorter wave-lengths of incident light.

13. The scattering of light by electrons. GEO. GLOCKLER, University of Minnesota.—On the principle of microscopic reversibility Klein and Rosseland (zeit. f. Phys. **4**, 46, (1921)) deduced the possibility of impacts of the second kind. Writing the reaction as a chemical equation, it is seen that the reverse reaction always represents the impact of the second kind. For example Hg $(1'S)+h\nu$ (2537A)$\rightleftarrows$Hg(2^3P_1) absorption and emission; M(normal$+h\nu\rightleftarrows$M(excited$+h\nu'$, Raman-effect: $h\nu+E^-$(slow)$\rightleftarrows h\nu'+E^-$(fast), Compton effect, where $h\nu'$ is the scattered quantum and E^-(fast) is the resulting photo-electron. On the principle stated above it is possible to predict the inverse effect, the scattering of light by fast electrons. The equations for head-on collision between a quantum and a free fast electron showing the change the wave-length is

$$\Delta\lambda=\left[(2h)/(mc)\pm 2\lambda_1\beta\right]\cdot\left[(1\pm\beta)\ (1\mp\beta)\right]^{1/2}$$

For a large quantum (x-rays) and a slow electron this reduces to Compton's equation. For visible light the ordinary Compton effect would be very small. However, the interaction of visible light with fast electrons should modify the quantum. The green line of mercury 5461A° should show a change of 685A when interacting with a 1000 volt electron in a head-on collision. The demonstration of this effect experimentally would depend upon the possibility of obtaining a powerful source of radiation and a dense electron-stream. In an arc or other source of radiation the above effect may be the cause of continuous spectra.

14. The effect of external fields on the polarisation of the light in hydrogen canal rays. I. WALERSTEIN, University of Toronto. (Introduced by A. J. Dempster.)—By means of a specially constructed aluminum cathode having a canal 6 mm long, it was possible to observe the light radiated by moving hydrogen particles before entering the canal, then in the canal itself, and finally in a high vacuum chamber beyond the canal in which the intensity of the light falls off exponentially. The effects on the polarization of the light was observed when electric and magnetic fields were applied in different directions. For weak magnetic fields applied perpendicular to the canal ray there is a decrease in the polarisation of the light in the canal. In the high vacuum chamber the polarisation ordinarily falls to zero a short distance from the canal end, but on applying magnetic fields this decay of the polarisation is disturbed and fluctuations in the polarisation occur which are nearly periodic along the canal ray. The periods increase with higher fields. The initial effect of the field begins closer to the canal end as the field is increased, there is a difference in the effect produced depending on whether the field is parallel or perpendicular to the direction of observation. Similar changes in the polarisation were also obtained when electric fields varying from 50 volts to 1200 volts were applied either along the canal ray or perpendicular to it.

FRIDAY AFTERNOON AT 1:30 O'CLOCK

Symposium—Physics Auditorium

FRIDAY EVENING AT 6 O'CLOCK

Dinner—Ballroom, Minnesota Union.

FRIDAY EVENING AT 8:15 O'CLOCK

Dedicatory Exercises—Physics Auditorium

For the Friday Afternoon and Evening programs, see pages 3–4.

SATURDAY MORNING AT 10 O'CLOCK

Paper No. 15 will be read by title.

15. Electrodeless ring discharge and the production of atomic rays of hydrogen. JACOB KUNZ, University of Illinois.—For the determination of the magnetic moment of the hydrogen atom a new method of production of atomic rays and a new slit system has been tested. The method consisted in inducing high frequency discharges in an electrodeless quartz bulb supplied with H_2. The bulb was connected to a quartz tube containing the slit system. The latter was made of semicircular quartz plates 1 mm thick, ground along the slit-forming edges to 0.03 mm, aligned and sealed at the ends of the quartz tube by special auxiliary apparatus. A thin platinum foil of 0.02 mm thickness, introduced between every pair of the semicircular quartz plates and then dissolved, left open well defined slits. The pressure of 2×10^{-4} mm was maintained in the slit system. A fine line of 0.05 mm thickness was obtained on the screen while the a.c. electromagnet was left unexcited. Remarkable, however, was the observation that whenever the magnetic field was applied the ring discharge was suddenly interrupted. Magnetic shielding of the disharge bulb and reduction of the magnetizing current from 8.5 to 3 amperes was required. A clean and sharp separation of the original line into two lines was then obtained.

Paper No. 16 will be read by title.

16. The positive ray analysis of hydrogen sulphide. JAMES H. BARTLETT, JR. Harvard University.—In the study of hydrogen sulphide by Dempster's method of positive ray analysis, three principal types of ion were found, namely $(H_2S)^+$, $(HS)^+$, and $(S)^+$, with ionization potentials of 11.1 ± 1.5 volts, 17.6 ± 1.5 volts, and 16.5 ± 1.5 volts, respectively. If the voltage scale be calibrated by assuming the correctness of Mackay's determination of the lowest

ionizing potential of hydrogen sulphide as 10.4 volts, then the corrected values of the ionizing potentials are approximately 10.4, 16.9, and 15.8 volts respectively. Neither $(S_2)^+$ ions, nor hydrogen ions, nor negative ions were observed. Variation of the pressure, at low pressures, shows that no secondary processes occur, i.e. that the ions $(H_2S)^+$, $(HS)^+$, and $(S)^+$ are all formed by the initial process of the electrons colliding with the gas molecules.

17. Measurement of the life of the metastable mercury atom. M. L. POOL Ohio State University.—A high speed disk has been used to interrupt the total radiation from a water-cooled and magnetically controlled quartz mercury arc that excited resonance radiation in mercury vapor contained in a quartz resonance tube at room temperature. Approximately 10^{-4} sec. after the optical excitation, a flash of visible radiation from another mercury arc was passed through the resonance tube and the absorption spectrum photographed. The line 4047 ($2^3P_0 - 2^3S_1$) showed strong absorption when a few millimeters of nitrogen were introduced into the resonance tube. The lines 4077, 4358, 5461, 5770 and 5790 showed no measurable absorption under similar conditions. The rate of decrease of the amount of 4047 absorbed with increasing time-wait after excitation of the mercury vapor was taken as the rate of decay of the metastable 2^3P_0 state. The life or half-value time of the state was found to vary markedly with the pressure of the admixed nitrogen. The maximum life, 4.2×10^{-4} sec., occured for 6.8 mm of nitrogen. No absorption of 4047 was observed upon the introduction of hydrogen, argon, neon or helium into the resonance tube.

18. Inelastic collisions of electrons with mercury atoms. JOHN D. WHITNEY, State Teachers College, Oshkosh, Wisconsin.—A beam of electrons is taken from a region containing Hg vapor into a highly evacuated space and is there spread out into a "velocity spectrum" by means of a magnetic field. The intensity of each component of the spectrum is measured for various initial energies of the electrons up to 40 volts. The ratio of the number of inelastic collisions of a given type at a given voltage to the number of elastic collisions at that same voltage is plotted against the initial energy of the electrons for the 4.9-, 6.7- and 8.8-volt types of collisions. Each curve shows a well-defined maximum in the range studied. For the 4.9-volt type it is at 7 volts; for the 6.7-volt type at 15 volts; for the 8.8-volt type at 12 volts. The heights of the maxima decrease in the order named. No evidence is found for collisions involving a loss of 10.4 volts.

19. Shot-effect in thermionic emission from oxide coated electrodes. N. H. WILLIAMS AND W. S. HUXFORD, University of Michigan.—Recent investigations in this laboratory have resulted in the successful determination of the charge of positive thermions from measurements of shot-effect. A special type of hot electrode made of barium oxide has been found to emit positive ions as well as electrons. The conditions are quite the reverse of those resulting in the case of positive ion emission from potassium-iron oxide crystals; in the latter the electron emission is very small in comparison to the ion emission, for low temperatures. Measurements of the ionic charge yield a value equal in magnitude to the charge of the electron, and the results are analogous to those obtained for K^+ ions from iron oxide crystals. In the present case space charge conditions are modified by the presence of large numbers of emitted electrons. Results of electron charge determinations are similar to those obtained with oxide coated filaments by J. B. Johnson. In the present study, however, the analysis is carried much farther and the limiting conditions obtained for a random electron distribution in the emission.

20. The effect of H_2O on the final positive air ion. HENRY A. ERICKSON, University of Minnesota.—The positive ion is produced in air or nitrogen which has been passed through calcuim chloride and phosphorous pentoxide at a rate sufficiently slow to reduce the amount of H_2O to a neglibile quantity. The initial positive ions are allowed to age until only the final 1.36 positive ions remain. H_2O is then added and the positive ions allowed to remain in the moist air for different intervals. It is found that the initial 1.87 ions again appear and the number of final 1.36 ions is diminished. As the time is increased more of the initial ions are obtained until a maximum is reached when the number of initial ions dimishes until only the final 1.36 ions are left. The number of final 1.36 ion during the above ageing dimishes to a

minimum, and then increases again in number. The minimum corresponds in time to the maximum for the initial ion. The explanation apparently is that the neutral H_2O molecule gives up an electron to the final 1.36 two molecule air ion thus forming a positive one molecule 1.87 H_2O ion which in turn attaches itself to a neutral molecule forming again a final 1.36 two molecule ion.

21. A test of the state of polarization of reflected electron waves. C. J. DAVISSON AND L. H. GERMER, Bell Telephone Laboratories, Inc.—An electron beam strikes a $\{111\}$-face of a nickel crystal at 45°. The reflected beam strikes a second similar crystal at the same incident angle. A Faraday collector receives those electrons which are reflected from the second crystal without loss of energy. The collector and second crystal are rigidly joined and and rotate about the axis of the beam proceeding from the first to the second crystal. Measurements upon the doubly reflected beam have been made at bombarding potentials from 10 to 150 volts. This beam exhibits five intensity maxima, at 20, 55, 77, 103 and 120 volts. Three of those maxima were observed in our reflection experiments (Proc. Nat. Acad. **14,** 624 (1928)—Fig. 3). The other two were outside the range of these experiments. Polarization of the electron waves reflected from the first crystal would manifest itself by a doubly periodic variation of collector current when the collector and second crystal are rotated. We observe no such variation. If it exists its amplitude is less than two percent of the total current, and in the case of the strong 120 volt beam is less than one percent. According to our observations electron waves are not polarized by reflection.

22. Velocity of cadmium atoms specularly reflected from rock salt crystals. A. ELLETT AND H. F. OLSON, University of Iowa.—Using a rotating sectored disc velocity analyzer we find that the beam of cadmium atoms specularly reflected from a clean rock salt crystal is composed of atoms having all very nearly the same velocity. This velocity varies with the angle of incidence, but not with the temperature of the crystal. The results may be represented by the equation

$$\lambda = h/M_H v = 2d\{\mu^2 - \mathrm{Sin}^2\theta\}^{1/2}$$

Here M_H is the mass of the proton, $\mu = 1.5$ the "index of refraction for phase waves." This equation may be interpreted in terms of d'Broglie's ideas by assuming that the periodicity associated with an atom is merely that characteristic of the protons which compose it. A similar result for the wave-length associated with the translation of a system of Z particles of equal mass may be obtained from Schroedinger's equation if the kinetic and potential energies both contain Z as a factor.

23. The resistance of mercury arcs. ALBERT W. HULL, General Electric Co.—The volt-ampere characteristic of a constant-pressure mercury arc is negative for small currents, nearly zero for moderate currents, and steeply positive for large currents. The positive portion has received very little attention. It has been described by Langmuir and Mott-Smith (G. E. Review, **27,** 770, (1924)) for the case of a discharge through a quartz capillary; but it does not appear to be known that this positive resistance is a general characteristic of low pressure arcs, occurring, for example, in the largest mercury arc rectifiers under operating conditions. Calculations of positive ion density by the method of Langmuir and Mott-Smith show that the positive resistance is always associated with the approach to complete ionization of the gas. The positive resistance is thus a normal characteristic of low pressure arcs, due to the increased energy necessary to maintain ionization when the fraction of atoms ionized becomes appreciable. Further evidence is furnished by the fact that two such arcs may be operated in multiple without stabilizing resistance or reactance, and share the current equally when the total current is sufficient to bring them into the positive resistance range.

24. The duration of the effect of ions on a negative space charge. C. BOECKNER AND F. L. MOHLER, Bureau of Standards.—A two electrode tube containing caesium vapor was operated under conditions described by Foote and Mohler (Phys. Rev. **26,** 195 (1925)) for detection of photoionization by the space charge effect of positive ions. Photographic records were obtained with a string galvanometer of the current rise and decay upon admitting and shutting off light. The effect requires one or two seconds to decay. The time-current curves follow the equations $d\Delta/dt = -\alpha I\Delta$ for decay and $d\Delta/dt = \alpha(I_f\Delta_f - I\Delta)$ for the rise. I is the

current at time t, I_f the final current after illumination while Δ and Δ_f are the differences between these currents and the dark current. α is a constant independent of the amount and place of illumination, of the voltage and current. It changes slowly with pressure and increases with filament area. An electric surge in a neighboring circuit produces a current which decays exactly like the photo-electric effect. Assuming that Δ measures the number of ions and therefore: $\alpha I\Delta$ their rate of dissappearance, then at equilibrium the light intensity must be proportional to $I\Delta$. Whitman has found this relation to hold (unpublished). The imprisonment of the ions in the potential minimum known to exist about a filament at low voltage may explain the long life.

25. The photographic activity of cod liver oil. JAY W. WOODROW, Iowa State College.—In the experiments described in this brief report it has been shown that the oxidation of cod liver oil is accompanied by the emission of particles which are capable of producing a developable image on a photographic plate. These particles experience only a small amount of scattering in passing through thin sheets of celophane and are only slightly deflected by a stream of air. The shadows which are produced by objects placed several millimeters from the photographic plate with a sheet of celophane placed between the object and the sensitive film, are much sharper than one would expect if it were a case of simple diffusion. The particles are completely absorbed by a few centimeters of air. The absorption in celophane obeys the ordinary exponential law, the coefficient of absorption being about 150 per cm. The effect is very much increased by a rise in temperature.

26. Becquerel effect in cells containing Grignard compounds. R. T. DUFFORD, University of Missouri.—Observations were made on nearly 100 cells containing anhydrous ether solutions of Grignard reagents (organo-magnesium halides), with various metals as electrodes. Such cells polarize readily, and show voltage drift, reversal, and oscillations, similar to effects shown to exist in aqueous solutions. The voltage of such cells is markedly sensitive to light, apparently to the longer visible wave-lengths. Some cells show an increase, some a decrease, of voltage on illumination. Temperature effects appear much too small to explain the observed changes, and are usually in the opposite direction. Each solution shows an optimum concentration for photo-sensitivity, this concentration being higher for aromatic than for aliphatic compounds. Results from eleven typical solutions indicate that the photo-sensitivity is most pronounced with the compounds that give the brightest luminescence on oxidation with oxygen.

SATURDAY AFTERNOON AT 2:30 O CLOCK

27. The M-series x-ray absorption spectra of metallic platinum and gold. ARTHUR J. M. JOHNSON, State University of Iowa.—The M-absorption spectra of metallic platinum (78) gold (79) have been investigated by the use of a vacuum spectrograph. Five discontinuities were found for platinum at wave-lengths of 5.711A (M_1), 5.506A (M_2), 4.677A (M_3), 4.085A (M_4), and 3.742A (M_5). For gold only four were found at 5.506A (M_1), 5.315A (M_2), 4.501A (M_3), and 3.603A (M_5). The $(\nu/R)^{1/2}$ values for the experimentally determined wave-lengths of these discontinuities compare well with the values predicted by the use of absorption and emission data from the L-series except for the M_1 and M_2 levels. For these two levels the measured wave-length values are unmistakably less than the computed values. This displacement of these two discontinuities for both of the elements investigated is in agreement with the results of others, (Zumstein, Phys. Rev. **25,** 747 (1925), and Rogers, Phys. Rev. **30,** 747 (1927)), upon neighboring elements of high atomic weight in which compounds of the elements were used in the absorption screens. The possibility of the displacement of these discontinuities being due to "chemical effect" is very remote. Since apparently the data from which the positions of the M-discontinuities are predicted are of more than sufficient accuracy to justify confidence in computations made with their use, it seems that the simple application of the combination principle in the prediction of these levels is not fully satisfactory.

28. X-ray anomalous dispersion in the region of the L series of platinum. ELMER DERSHEM University of California.—The indices of refraction of platinum in the neighborhood of its L absorption limits were measured by the total reflection method. When values of $1-\mu=\delta$

are plotted against the corresponding values of λ one depression in the curve shows lowered values of δ at a wave-length corresponding to a mean of the wave-lengths of the L_I and L_{II} limits and another at the L_{III} limit. Evidently the L_I and the L_{II} limits are not resolved because of relatively small wave-length separation, whereas in the case of silver (Phys. Rev. **31,** 1117, (1928)) the L_{II} and L_{III} were not resolved. In the latter metal these levels are closer together than L_I and L_{II}. Using a platinum film nearly opaque to light, values of δ in fair agreement with theory were obtained. A thinner film, estimated as transmitting at least 80 percent of visible light, gave a curve whose δ values were at all points about 25 percent higher than for the nearly opaque film. Other experiments are cited which show that different surfaces of the same material may have very different indices of refraction.

29. Wave-length measurement of γ-rays from radium and its products. L. T. STEADMAN, Yale University. (Introduced by A. F. Kovarik.)—The work of Kovarik in this field has been continued using the method of crystal diffraction. γ rays from a 5 mg Ra source are limited by a slit of 3 mm width between two lead blocks 7 cm in thickness and incident on a crystal of calcite fixed in position at 20 cm. Those rays which are diffracted on transmission come to a focus at 40 cm from the source and are detected by a Geiger counter employing an amplifier and loud speaker. Two lead blocks 15 cm in thickness are used to form a slit 0.3 mm wide in front of the chamber and may be rotated about the focus as an axis, the angle being read to 7 sec of arc. Results in good agreement with the previous workers, Rutherford-Andrade, Kovarik, Ellis-Skinner, and Frilley have been found. The following are some of the lines measured in X.U. $68 \cdot 1^2$, $34 \cdot 1$, $25 \cdot 9$, $38 \cdot 9^2$, $27 \cdot 9$, $23 \cdot 9$, $21 \cdot 1^2$, $19 \cdot 7$, $17 \cdot 6^2$, $16 \cdot 2$, $12 \cdot 3$, $10 \cdot 6$, $5 \cdot 3$. (^{2} probably second order). There are other lines in evidence of intermediate and also of shorter wave-length. These will be measured and all repeated with greater accuracy.

30. The space group and crystal structure of potassium sulphate. FRANK PEAT GOEDER, University of Chicago. (Introduced by J. K. Morse.)—Crystals were grown by evaporation. Sections cut parallel to the 100, 010 and 001 faces were mounted on perforated glass slides and a series of Laue photographs obtained. Analysis of these photographs placed potassium sulphate uniquely in space group $2Di$-13, (V_h^{13}). Powder photographs were then made using a General Electric apparatus. Analysis of these negatives gave the following values of the lattice constants, $a_0 = 5.771$, $b_0 = 10.064$, $c_0 = 7.518$A. The following positions gave the best agreement with all diffraction results

Potassium 000; 1/2 0 1/2; 0 1/2 1/2; 1/2 1/2 0; 0 0 1/2; 1/2 0 0; 0 1/2 0; 1/2 1/2 1/2

Sulphur 0 1/4 1/2; 1/2 1/4 0; 0 3/4 0; 1/2 3/4 1/2

Oxygen (.00, .15, .30); (.25, .35, .50); (.00, .15, .70); (.25, .35, .00); (.50, .15, .20); (.50; .15, .80); (.75, .35, .00); (.75, .35, .50); (.00, .65, .20); (.00, .65, .80); (.50, .65, .30); (.50, .65, .70); (.25, .85, .00); (.25, .85, .50); (.75, .85, .00); (.75, .85, .50).

A comparison between the relative intensities observed and those computed from the structure quantitatively verified this arrangement. Two points may be emphasized. (1) the potassium sulphate molecule is clearly defined in the crystal and consists of a tetrahedral arrangement of the oxygen atoms having the sulphur at the center and the two potassium atoms on a straight line and equidistant from the sulphur atom; (2) while the potassium ions have the general positions of the space group, the sulphur atoms do not fit any special cases of the general arrangement.

31. The crystal structure of solid mercury. KARL LARK-HOROVITZ, Stanford University and Purdue University.—Applying the method used previously by the author in the investigation of the crystal structure of the alkali metals, (Phys. Rev. **29,** 352 (1927)) thin deposits of solid mercury were formed in a high vacuum and their crystal structure determined at different temperatures. The mercury was first condensed at liquid air temperature and sharp lines were obtained with copper and iron K radiation (in about 500 M.A. min.) confirming McKeehan's results. The mercury condensed at liquid air temperature was then brought up to the temperature of a carbon-dioxide-alcohol mixture and the crystal structure at this temperature was determined. It is found to be identical with the structure at lower temperature: the statement of former investigators that a different form of mercury exists at $-80°$C is therefore erroneous. Whereas the geometry of the lattice is identical, the lines are sharper at the higher temperature,

and their relative intensity is sometimes changed, indicating an orientated growth of the crystals in warming up and recrystallizing.

32. Diffraction of x-rays in liquids: benzene, cyclohexane and certain of the irderivatives. G. W. STEWART, University of Iowa.—An examination by the x-ray diffraction ionization method was made of benzene, toluene, *o*-, *m*- and *p*-xylene, mesitylene, ethyl benzene and iso-propyl-benzene; cyclohexane, methyl cyclohexane, *o*-, *m*- and *p*-dimethyl cyclohexane; phenol, aniline, cyclohexanol and cyclohexanone. The cybotactic condition in the liquid and the applicability of Bragg's Law in determination of separation of diffraction centers, are assumed. The structure of the benzene and cyclohexane rings are shown to be distinctly flat, having a thickness of 4.70A and 5.10A, respectively. Computing for density and assuming the groups to be parallel discs each occupying a hexagonal area, the distance between two parallel sides of the hexagon is 6.0A in benzene and 6.4A in cyclohexane. These rings are so effectively flat that simple substitutions like OH and NH_2 with the benzene ring and O in the cyclohexane ring do not increase the thickness by a well defined amount. The substitution of a CH_3 group increases the thickness by 0.36A and 0.25A, respectively. In substituting two CH_3 groups in the ortho, meta and para positions, there is a striking simularity of the changes in the thickness of the ring, it being greatest in the ortho position and least in the para position, the effect with benzene being the greater. The two polar compounds, phenol and cyclohexanol, show the association of molecules, the polar end groups uniting with the molecules end to end and parallel to adjacent molecules, and lying in planes perpendicular to the planes containing the "discs."

Paper No. 33 will be read by title.

33. The effect of x-rays on the rotatory power of some substances. A. A BLESS, University of Florida.—According to Allison, (Phys. Rev. **31**, 159, (1928)) x-rays falling on water and on some organic compounds affect the power of these substances to rotate the plane of polarization of light passing through them. Experiments were made to discover a similar effect of x-rays on quartz crystals. A molybdenum water-cooled Coolidge tube operated at about 40,000 volts served as a source of x-rays. A half shadow type polarimeter on which readings could be made to 0.01 degrees was used. The quartz crystals ranged in thickness from 0.5 cm to 1.5 cm. No effect of x-rays on the rotation of the plane of polarization of light passing through these crystals was discovered. The error in "setting" was about 0.1 degrees. Experiments with water, sugar solutions and xylene also failed to yield the positive results obtained by Allison, although the error in setting for the organic solutions was about 0.6 degrees and for water, through which white light was allowed to pass instead of monochromatic as in the other cases, the error was less than 0.02 degrees. The tube containing the liquids was 22 cm long. The experimental work was done at Cornell University.

34. A mechanical analog to the hydrogen wave equation. J. H. VAN VLECK, University of Wisconsin.—This is only an elementary remark on how to visualize without mathematical analysis why positive energies are continuous, negative discrete. The hydrogen wave function is $\psi = S(\theta, \phi)f(r)$, where S is a tesseral harmonic and where, using the notation x, t rather than f, r, the equation for the radial factor is

$$\frac{d^2x}{dt^2} + \frac{2}{t}\frac{dx}{dt} + \frac{8\pi^2 m}{h^2}\left[W + \frac{a}{t} + \frac{b}{t^2}\right]x = 0.$$

This may be interpreted as the equation of an oscillator whose damping factor and restitution coefficient vary with the time. If $W>0$, this coefficient is positive for large values of t, and vibrations damp down to the equilibrium position $x=0$ at $t=\infty$ regardless of initial conditions. (Comparison with Bessel's Eq. shows the damping adequate despite the factor $2/t$.) Now there is always one solution finite at $r=0$, and from the preceding this solution will vanish properly at $r=\infty$ whenever $W>0$. Hence all positive W's are characteristic values. With $W<0$, the restitution coefficient is negative for large t, and consequently except under very special conditions the displacement x will tend to increase indefinitely as t approaches infinity. Thus it is plausible that only particular negative values of W make the solution which is finite at $r=0$ also finite at $r=\infty$.

35. Nuclear motions associated with electron transitions in diatomic molecules. E. V. CONDON, Princeton University.—The question of nuclear motions associated with electron transitions is discussed from the standpoint of quantum mechanics. It appears that Heisenberg's indetermination principle gives the clue to the inexactness of the earlier method (Phys. Rev. **28,** 1182, (1926)) based on Franck's postulate since its strict application calls for a violation of the principle. The existence of an entirely new type of band spectrum due to the wave nature of matter is predicted and the interpretation of Rayleigh's mercury band at 2476–2482A as of this type is suggested. Finally it is shown that while Franck's postulate is also true for electron jumps in atoms, it is of but trivial interest because its inexactness is much greater for the electrons than for heavy nuclei. The complete paper appears in the *Physical Review* for December, 1928.

36. Wave mechanics and radioactive disintegration. RONALD W. GURNEY AND EDW. U. CONDON, Princeton University.—Hitherto the "instability" of the radioactive nucleus has remained a mystery. But if the nuclear particles obey the laws of wave mechanics, the spontaneous disintegration of the nucleus by the emission of a particle may ensue. For by the wave mechanics particles are enabled to pass through regions in which their total energy would according to the classical mechanics be less than their potential energy. Thus a nuclear particle always has a certain probability of penetrating the barrier of potential which confines it, and of escaping from the nucleus. Any radioactive decay period from a fraction of a second to over 1010 years is easily obtained. For elements which expel particles we expect a relation between the rate of decay and the energy of the emitted particle of the same kind as that given by the Geiger-Nuttall relation. In favor of this theory of radioactivity there is the additional fact that it predicts the well known paradoxical result found by Rutherford and Chadwick for the scattering of fast α particles fired at a film of uranium. A preliminary note by the authors on this subject appeared in *Nature* for Sept. 22nd.

37. On the separability of Schoedinger's equation for the asymmetrical top. S. C. WANG, National Research Fellow, University of Wisconsin.—By utilizing the results of Reiche on the problem of the asymmetrical top in the old quantum theory (Phys. Zeits., **19,** 394, (1918)), it is found that Schroedinger's equation for this problem is completely separable, when the spatial quantum number m is zero, in the set of coordinates introduced by Reiche. The two resulting ordinary differential equations, except for a difference in boundary conditions, are both of the form $(f(\lambda)/\lambda)^{1/2}d/d\lambda\left[(f(\lambda)/\lambda)^{1/2}d\overline{U}/d\lambda\right]+(a+b/\lambda)\overline{U}=0$, where λ is one of the two elliptical coordinates λ_2 or λ_3 and $f(\lambda)$ a cubic, for the definition of all of which we refer to Reiche's original paper; and where $\overline{U}$ stands for $\overline{U}_2(\lambda_2)$ or $\overline{U}_3(\lambda_3)$ and a and b are two constants common to the two equations. The above equation resembles closely the generalized Lamé's equation investigated by Klein and Bôcher. A geometrical argument similar to the one used by Klein shows that there exist two sets of characteristic values for the constants a and b which specify admissible solutions in λ_2 and λ_3 respectively. Closed forms for the characteristic values and the characteristic functions have not yet been obtained.

38. Radiation by accelerated electron in classical electron theory. JOHN A. ELDRIDGE, University of Iowa.—It is considered fundamental in the classical electron theory that an accelerated electron must radiate energy. This appears to be contradicted by the older forms of the quantum theory. In the classical proof it is assumed that an electron charge surrounded by a static field is suddenly accelerated. Retarded potential solutions involving radiation of energy follow. But, it would seem that the initial conditions (of an accelerated charge in an undisturbed field!) are physically unrealizable. Whether or not radiation occurs appears to depend entirely upon the initial field conditions and those assumed in the usual theory are impossible.

39. Confirmatory experimental evidence of gas degeneration and the applicability of Pauli's exclusion principle to metallic conduction electrons. JESSE DU MOND, California Institute of Technology.—From the breadth and structure of the Compton shifted line the distribution of velocities of the scattering electrons can be inferred, the effect being similar to the Doppler broadening of optical lines. The structure of this line has been studied experimentally with a spectrograph contained in the x-ray tube for scattering by aluminum and

beryllium at nearly 180° scattering angle. The results are compared with the line structure to be expected from the three following assumptions; first, that conduction electrons share classically in equipartition of the thermo-kinetic energy of the crystal; second, that they have the same velocities as they would have in the outer orbits of isolated atoms; third, that they are subject to the Pauli exclusion principle and have the velocity distribution predicted by Sommerfeld. The results are found to definitely support the third assumption.

Paper No. 40 will be read by title.

40. The atomic electric charges in the electromagnetic quantum theory. CORNELIO L. SAGUI, Castelnuovo dei Sabbioni, Arezzo, Italy.—Gravity is supposed to be due to a magnetic depression between two bodies resulting from the reaction of opposed magnetic lines (gravity lines). Again repelling forces result from the contact of two quasi-definite energy-levels as an increase of magnetic quanta results at the contact. If it were possible to overcome the repelling forces the two bodies would unite in a new unit with a common quasi-definite energy-level. The positive and negative atomic charges would be a particular case of the general one mentioned. An electron, with decreasing density from the center, would establish a negative potential outward causing tiny radial currents with a dextrorotatory magnetic field. A proton formed by 1830 electrons would have two magnetic fields for each energy-level, one outside, dextrorotatory, and another, laevorotatory, inside. The latter for structural reasons would be larger and the difference for the whole energy-levels would be the positive magnetic mass μ which is 1/5 of the whole. $\mu = 1/5 \times 2/3 \times (5.5 \times e^2 \times 10^4)/1.8 \times 10^{-9} \times c^2 = 2/3 e^2/1.9 \times 10^{-13} c^2$ (electro-magnetic mass). The number of electrons of an average shell, with a radius of 1.8×10^{-9} cm, representing the proton, is $5.5 \times e^2 \times 10^4$.

SUPPLEMENTARY PROGRAM

When two or more papers are offered by the same member, one only of these will be assigned a place on the regular program, while the others will be placed in a supplementary program, to be called for if time permits.

Papers received after the program has been printed will be placed in the supplementary program.

Paper No. 41 will be read by title.

41. Measurement of electrical fluctuation phenomena. HAROLD A. WHEELER, Johns Hopkins University.—In experimental work on the "shot effect" and "flicker effect" in vacuum-tube amplifiers and on the "thermal agitation" in electric conductors, it has been customary to amplify and rectify the fluctuations, and to observe directly their mean square amplitudes. An alternative method of measurement has been developed in which the fluctuations are amplified and made to cause a proportional agitation of the indicator of a galvanometer. The average deviation of the indicator from its zero position is determined by a series of observations, and the mean square amplitude of the fluctuations is computed therefrom. This method is especially applicable to the measurement of fluctuation components within frequency bands less than one cycle wide, at audio or subaudio frequencies. The flicker effect has been measured in two different amplifiers, in one case within a frequency band 0.4 cycle wide at 0.4 cycle resonant frequency, and in the other case within a frequency band 1.0 cycle wide at 150 cycles. These observations indicate that the flicker effect may be caused by disturbances of several seconds duration. The thermal agitation in a resistance of 10^7 ohms was measured by the latter amplifier; the agreement with the theoretical value was well within the probable error of the experimental value (8%).

42. A promising method for measuring x-ray intensities. R. T. DUFFORD AND H. E. HAMMOND, University of Missouri.—Three types of cells have been found which under influence of x-rays of average intensity give a photo-voltaic response of from 0.2 to above 0.8 volt; and on closed circuit give a current response considerably larger than could be obtained from ordinary ionization chambers. Certain of these cells reach the maximum response, and recover

from it, in less than two seconds. The amount of the response is probably the largest on record for photo-voltaic cells. The voltage change appears to be approximately proportional to the logarithm of the x-ray intensity. Further study is in progress.

43. Polarization of cadmium resonance radiation 1^1S_0–2^3P_1 3261 A. A. ELLETT, University of Iowa.—This resonance line excited by plane polarized light is completely polarized in the absence of a magnetic field, and also in a field parallel to the electric vector of the exciting light. The radiation emitted in the direction of a magnetic field perpendicular to the exciting electric vector is rapidly depolarized with increase of the applied field, the observed points lying on the curve $P=1/(1+3640H^2)$, where $P=(I_z-I_y)/(I_z+I_y)$ I_z and I_y being the intensities of the radiation polarized respectively parallel and perpendicular to the exciting light vector. Both Eldridge and Breit have shown that the above relation is $P=1/([1+2(geH\tau/2mc)^2]$ so that τ, the mean life of the 2^3P_1 state of cadmium is $2.30\ 10^{-6}$ secs. Soleillet has recently given .92% as the polarization of this line in zero field. (C. R. Vol. **142**.) That this may be due to the depolarizing action of collisions is suggested by the fact that he likewise finds a smaller $\tau=2.0\times10^{-6}$ secs.

44. Reflection of atoms from crystals. A. ELLETT AND H. A. ZAHL, University of Iowa.—Cadmium and arsenic are diffusely reflected from crystals of flourite and orthoclase. A cadmium beam striking a KCl crystal gives rise to a distinct specular beam, but its intensity relative to that diffusely scattered is much less than in the case of Cd and NaCl crystals. Arsenic (As_4?) incident upon NaCl gives rise to a weak specular beam with much diffuse scattering. Arsenic deposited upon a glass surface at liquid air temperatures is transparent in layers of such thickness that when warmed to room temperature they transmit but 10 or 15% of the incident light. Very thick layers deposited at liquid air temperature are black. Such deposits as they warm to room temperature change very abruptly to a deep red—then a bright yellow, and finally to the usual steel grey modification.